PATENT SPECIFICATION (11) 1 265 770

DRAWINGS ATTACHED

1 265 770

(21) Application No. 31866/70 (22) Filed 1 July 1970
(31) Convention Application No. 838 257 (32) Filed 1 July 1969 in
(33) United States of America (US)
(45) Complete Specification published 8 March 1972
(51) International Classification B 01 j 1/00 9/20
(52) Index at acceptance
B1F 3A1A 3A2

(54) FLUIDISED BED REACTOR

(71) We, MONSANTO COMPANY, a corporation organised under the laws of the State of Delaware, United States of America, of 800 North Lindbergh Boulevard, St. Louis 66, State of Missouri, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention relates to a catalytic reactor for use in fluidized bed operations. More particularly, the present invention relates to a catalytic reactor for use in the production of unsaturated aldehydes and acids from olefins and oxygen or the production of unsaturated nitriles from olefins, oxygens and ammonia.

The oxidation of olefins to produce unsaturated aldehydes and acids or the ammoxidation of olefins to produce unsaturated nitriles is well known. In particular, the production of acrylonitrile from the reaction of oxygen, propylene and ammonia is a widely used commercial process. The above processes are generally carried out in a fluidized bed reactor wherein the reactants are passed upwardly through a suitable catalyst, the products and any unreacted starting materials being removed from the top of the reactor. The catalyst used in these processes have been fully described in the prior art. See, for example, U.S. Patent 2,904,580, British Patent 824,666, British Patent 876,446, U.S. Patent 3,198,750, and U.S. Patent 3,254,110. In general, these catalysts are quite expensive and consequently it is necessary that the utmost efficiency be achieved in their use. Any unnecessary loss or deactivation of the catalyst must be avoided to minimize operating costs. Since these catalysts must be kept in their oxidized state to retain activity, it is expedient that they be maintained in contact with the oxygen used in the processes.

Most fluidized bed reactors are composed basically of a suitable chamber in the lower portion of which is mounted a perforate distributor plate which serves the dual purpose of supporting the catalyst and diffusing the gaseous reactants upwardly thereinto at a rate sufficiently high enough to effect fluidization of the catalyst.

In many reactors presently employed in the above described oxidation and ammoxidation processes, there is a tendency for the catalyst to accumulate near the inside wall of the reactor on the perforate plate, i.e. in the corners of the reactor where the inside walls and the perforate plate are joined. This unfluidized catalyst which accumulates in the corners is subject to reduction due to the fact that it is not maintained in the fluidized-oxidizing section of the reactor, i.e., it is not adequately contacted by the oxygen of the feed reactants. In commercial reactors employing large charges of catalyst, this accumulation can become significant and results in high catalyst cost plus decreased production of the desired products.

It is, therefore, an object of the present invention to provide an improved catalytic reactor for use in fluidized bed operations, the improvement consisting in an arrangement whereby minimum stagnation of the catalyst occurs.

The reactor of the present invention comprises a housing, a distributor plate mounted transversely in the lower portion of the housing and joined at its periphery to the wall of the housing, means for introducing a fluid reactant into the housing below the distributor plate, a conduit within the housing located above and adjacent the peripheral area of the distributor plate and having a plurality of orifices facing the said area, means for introducing a fluid into the conduit and means for removing reactor effluent from the upper portion of the housing.

In a particular embodiment of the invention, the reactor comprises a housing for enclosing a bed of catalyst fluidizable by passage of fluid upwardly therethrough; a distributor plate mounted in said housing above its lower end to support said catalyst, a plenum being formed in the space bounded by said distributor plate and said lower end of said housing; means for introducing at least one fluid reactant into said plenum and thence upwardly through said distributor plate through said catalyst; an annular conduit mounted substantially concentrically in said housing above said distributor plate, said conduit having a plurality of orifices facing said distributor plate; means for introducing a fluid into said conduit, said conduit being positioned such that said fluid, upon passing through said orifices, serves to fluidize catalyst accumulated adjacent the outermost portion of said distributor plate; and means for removing reactor effluent from the upper portion of said housing.

In the accompanying drawings:—

Figure 1 is a partial elevation with parts broken away and in section of the reactor of the present invention.

Figure 2 is a view of Figure 1 taken along the line 2-2.

Figure 3 is a view of Figure 1 taken along the line 3-3 showing the secondary reactant feed distributor.

Figure 4 is an enlarged sectional view taken along the line 4-4 of Figure 2.

While the description given herein will be with reference to a process for the production of acrylonitrile from oxygen, propylene and ammonia, it is to be understood that the present invention is useful in any fluidized bed operation where accumulation and non-fluidization of catalyst is to be avoided, and where the fluid may be either liquid or gas.

At least one of the fluid reactants is introduced via conduit *10* into a plenum *11* formed by the bottom walls of reactor *12* and distributor plate *13*. The reactant or reactants pass through the nozzles *14* attached to the bottomside of distributor plate *13* and thence upwardly through the catalyst shown generally at *15*. For simplicity, the nozzles *14* are shown as welded at *16* to the bottom of the distributor plate *13*. However, it is obvious that numerous other methods of attaching the nozzles to the bottom of the distributor plate may be employed. The reaction products plus any unreacted starting material are removed from the upper part of reactor *12* by a suitable means (not shown). Distributor plate *13*, as shown, and in the preferred embodiment is dish-shaped, the greater central portion of distributor plate *13* being substantially planar while the outermost portions adjoining the walls of reactor *12* are concave. It is to be understood, however, that a completely flat or completely concave distributor plate may also be used. Sparger ring *17* which is an annular conduit, preferably having a circular cross-section, is positioned concentrically within reactor *12* in the corner formed by the intersection of the inside walls of reactor *12* and the outermost portion of distributor plate *13*, sparger ring *17* being held in place by mounting brackets *18*. Sparger ring *17* contains a plurality of orifices which in the preferred case are equally spaced and have shrouds *19*, shrouds *19* being attached by welding *20* to ring *17*. While orifices *21* are seen to have a smaller diameter than the inside diameter of shrouds *19*, this is a preferred embodiment only and is not a necessary feature. Feed line *22* supplies a fluid to sparger ring *17*. Line *22*, as shown, is in open communication with reactant feed line *10* such that the fluid passing through line *22* into sparger ring *17* and thence out of orifices *21* and shrouds *19* into the corners of reactor *12* is a portion of the fluid reactants being fed into plenum *11*. The fluid passing through sparger ring *17* and thence out of orifices *21* and shrouds *19* has the effect of fluidizing any quiescent catalyst shown generally at *23* as a heavier concentration of catalyst which may accumulate in the corners of reactor *12*. As also seen in Figures 1 and 3, reactor *12* contains a secondary feed distributor system whereby at least one or more fluid reactants can be fed directly to the catalyst bed. The secondary reactant feed distributor system comprises a main line *24* which is in open communication with a plurality of pipes *25*. As shown, pipes *25* are sealed on one end, the other end being connected to line *24*. Pipes *25* and line *24* have a series of uniformly distributed orifices *26* in the bottom side facing the orifices in distributor plate *13*. Shrouds *27* attached to the bottom side of pipes *25* and line *24* direct the fluid passing through orifice *26* into the catalyst bed *15* and serve to reduce the velocity of the fluid entering the bed. As will be obvious to those skilled in the art, the design of the secondary distributor system shown is merely illustrative of many types of such systems which can be employed.

A reactor basically as described above was employed in the synthesis of acrylonitrile. The reactor had an inside diameter of approximately 22 ft. The pipe from which the sparger ring was constructed had an inside diameter of approximately 4" and the orifices on the bottom portion facing distributor plate *13* had a diameter of approximately 7/16 of an inch and a 6-9/16" center-to-center spacing. The

shrouds around the orifices consisted of 6" lengths of 3/4" schedule 40 standard pipe. The sparger ring was positioned within the reactor such that it was approximately 4" from the inside wall, the bottom of the shrouds being approximately 4" from the concave portion of the distributor plate. The feed line to the sparger ring consisted of a 4" diameter pipe mounted through the reactor wall and welded to the sparger ring. A 6" diameter feed line to the sparger ring was also connected to the main reactor feed line going to the plenum.

In an actual plant run for the synthesis of acrylonitrile employing the reactor without a sparger ring and using a feed mixture of ammonia, propylene, air and steam with an antimony oxide-molybdenum oxide based catalyst, it was found that a build-up of quiescent catalyst occurred on the outermost portion of the distributor plate nearest the inside walls of the housing. Under very similar conditions but using a reactor as described herein with the sparger ring, no catalyst accumulation was noted on the outermost portions of the distributor plate. In other words, the use of the reactor herein with the sparger ring minimized the presence of quiescent catalyst in the reactor. As mentioned above, the oxidation or ammoxidation of olefins employs catalysts of relatively high cost. When the catalyst is in a quiescent state in the reactor, it is not in the oxidizing-fluidizing portion thereof with the consequence that it may undergo reduction. The reduced catalyst displays loss of selectivity and activity which results in lower product make and increased catalyst cost.

The materials of construction of the reactor, distributor plate, secondary distributor, sparger ring, etc., are purely a matter of choice depending on the reaction being carried out. All that is necessary is that the materials be of a type suitable to withstand the reactants, temperatures and pressures employed in the reaction being carried out.

The type, size, etc., of the nozzles on the distributor plate and the secondary distributor is a matter of choice depending on the precise reaction being carried out. Also, while in the above description the nozzles are shown as being on the bottom side of the distributor plate, distributor plates having nozzles extending upwardly into the reactor housing can also be employed. When the reactor herein is used for the production of aldehydes, acids or nitriles as described above, it is preferred to use a distributor plate with downwardly pointing nozzles.

The size of the sparger ring, the size, number and spacing of the orifices, the size of the feed line to the sparger ring and the diameter and length of the shrouds around the orifices, in general, are dictated by the size of the reactor being employed. Usually, however, the orifices in the sparger ring will not be greater than 1" in diameter and the spacing not greater than 24" on centers. The diameter of the feed line to the sparger ring can be smaller than, equal to, or greater than the diameter of the sparger ring itself.

The feed line to the sparger ring need not be connected to the main feed conduit, i.e., it is not necessary that the fluid passing to the sparger ring be the same as the main reactant feed although in the preferred case the sparger ring feed and the main reactant feed are the same. Furthermore, although only a single feed line is shown to the sparger ring, a plurality of feed lines can be used if desired. Likewise, a plurality of feed conduits to the plenum of the reactor can be employed rather than one as shown. While the reactor, as shown, contains a secondary feed distributor to feed fluid reactants directly into the catalyst bed, it is to be understood that this is a preferred and not a necessary feature of the reactor. It is entirely possible to operate the reactor in the absence of any secondary feed distribution system. Furthermore, while, as described, the feed to the plenum in the bottom of the reactor and the secondary feed distribution are separate, they need not be. It is possible and may in some cases be desirable that the secondary feed distributor system be used to feed the same reactants to the catalyst directly as are being fed to the plenum located in the bottom of the reactor. As will be obvious, this can be accomplished merely by connecting line *24* to line *10* is some appropriate fashion. In general, when a secondary feed distributor system is employed, it will be located in the bottom quarter of the reactor in order to provide adequate mixing of the reactants at the base of the fluidized bed. As is the case with the nozzles on the distributor plates in the bottom of the reactor, the shrouds on the secondary feed distribution system can be of various lengths depending on the exact configuration of the reactor and its intended use.

The sparger ring should be positioned within the housing uniformly above the distributor plate and such that the fluid passing through the orifices and shrouds will fluidize any quiescent catalyst which has accumulated at the outermost portions of the distributor plate. Obviously, the precise positioning will depend on the catalyst properties and the reactor parameters. In general, however, the sparger ring will be located such that the perpendicular distance from a plane determined by the bottom side of the sparger ring to a plane determined by the planar upper surface of the distributor plate is not greater than 1 ft. As noted, the

sparger ring is mounted concentrically within the reactor housing. Generally speaking, the diameter of the circle determined by the sparger ring will be at least 90% of the inside diameter of the reactor housing.

While not showing in the drawings, it is obvious that the reactor herein may have other features. For example, cyclone separators located in the upper portions of the reactor are generally employed to separate catalyst mechanically carried upward by the reaction fluids. The cyclone separators which are well known can be of various designs. Furthermore, the reactor may be equipped with devices such as temperature and pressure measuring elements, means to introduce gases into the central portion of the reactor housing, heat exchanging systems to add or to remove heat to the catlyst and the like.

As has been pointed out, the reactor herein finds special usage in the oxidation and/or ammoxidation of olefins to produce unsaturated acids, aldehydes and nitriles. It is obvious, however, that the reactor has utility in any fluidized bed operation where a reactor of similar design is employed and where there exists the possibility of quiescent catalyst build-up on the outermost portion of the distributor plate.

WHAT WE CLAIM IS:

1. A reactor for carrying out fluidised bed reactions comprising a housing, a distributor plate mounted transversely in the lower portion of the housing and joined at its periphery to the wall of the housing, means for introducing a fluid reactant into the housing below the distributor plate, a conduit within the housing located above and adjacent the peripheral area of the distributor plate and having a plurality of orifices facing the said area, means for introducing a fluid into the conduit and means for removing reactor effluent from the upper portion of the housing.

2. A catalytic reactor comprising:

a housing for enclosing a bed of catalyst fluidizable by passage of fluid upwardly therethrough;

a distributor plate mounted in said housing above its lower end to support said catalyst, a plenum being formed in the space bounded by said distributor plate and said lower end of said housing;

means for introducing at least one fluid reactant into said plenum and thence upwardly through said distributor plate through said catalyst;

an annular conduit mounted substantially concentrically in said housing above said distributor plate, said conduit having a plurality of orifices facing said distributor plate;

means for introducing a fluid into said conduit, said conduit being positioned in said housing such that said fluid upon passing through said orifice serves to fluidize any quiescent catalyst accumulated adjacent the outermost portion of said distributor plate; and

means for removing reactor effluent from the upper portion of said housing.

3. A reactor according to Claim 2 wherein the distributor plate has a plurality of uniformly distributed substantially circular orifices, the orifices having nozzles extending downwardly from the distributor plate into the plenum.

4. A reactor according to either of Claims 2 and 3 wherein the distributor is substantially dish shaped, the greater central area of the plate being planar, and the outermost portion of the plate adjacent the interior walls of the housing being substantially concave in shape.

5. A reactor according to any of Claims 2 to 4 wherein the orifices in the conduit are substantially equally spaced.

6. A reactor according to any of Claims 2 to 5 wherein the orifices in the conduit are shrouded.

7. A reactor according to any of Claims 2 to 6 wherein the means for introducing a fluid into the conduit is connected to the means for introducing the fluid reactant into the plenum.

8. A reactor according to any of Claims 2 to 7 having a means for feeding at least one fluid reactant directly into the fluidized bed above the distributor plate.

9. A reactor according to either of Claims 1 and 2 substantially as described with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1972. Published at the Patent Office, 25 Southampton Buildings, London WC2A 1AY from which copies may be obtained.

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2 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

Fig. 1.

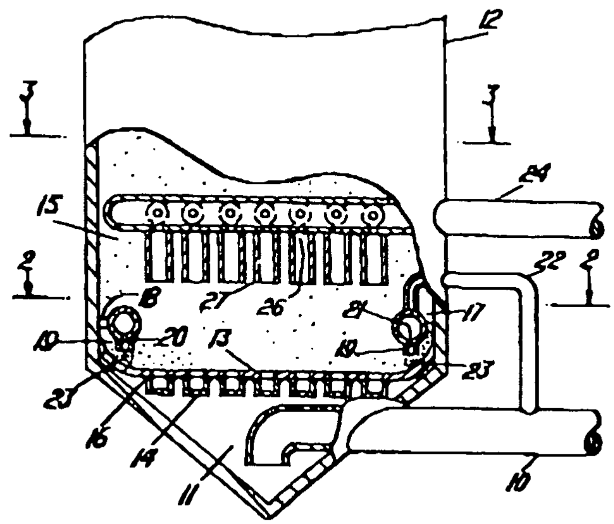
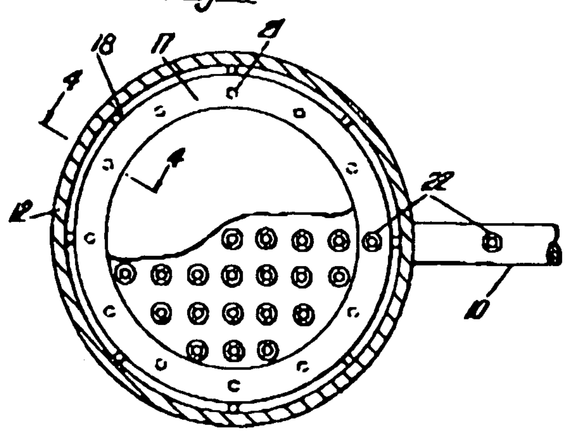


Fig. 2.



1,265,770 COMPLETE SPECIFICATION
2 SHEETS
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SHEET 2

Fig.3.

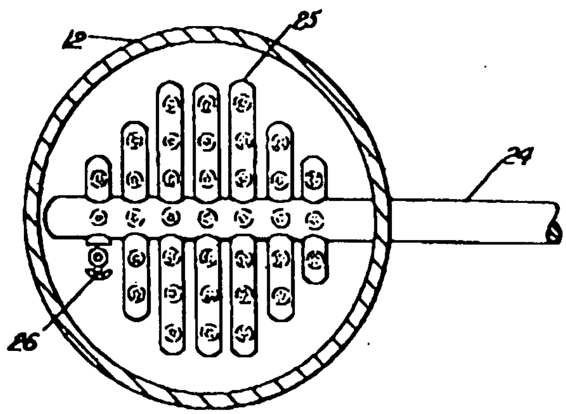

Fig.4.